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Section 7: Non-Crystalline materials

A.C. ELECTRICAL CONDUCTION IN $As_2Te_{2.8}Si_{3.2}$ BULK GLASS

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Electrical conduction of $As_2Te_{2.8}Si_{3.2}$ glass has been investigated at frequencies situated in the range 10 kH-10 MHz, at room temperature. A mixed mechanism of a.c. conduction: hopping conduction and inhomogeneity conduction is suggested.

Keywords: Ternary glass, As-Te-Si, a.c. conductivity

1. Introduction

Amorphous and glassy chalcogenides are intensively studied due to properties useful in optoelectronic applications. Since switching phenomena were observed in vitreous materials based on tellurium [1] the electrical properties of chalcogenide glasses have attracted much attention [2].

The structure and properties of ternary glasses are of interest in relation to the role played by the chalcogen element in the metastability of the material subjected to external factors as temperature, pressure or electrical field.

Recently, we have studied the d.c. electrical conduction properties of the bulk glass $As_2Te_{2.8}Si_{3.2}$ [3]. The investigated material is situated not very far from the glassy composition with the highest softening temperature in the ternary system As-Te-Si: $As_2Te_4Si_4$.

In this paper we report the results of a study regarding the a.c. conductivity of the $As_2Te_{2.8}Si_{3.2}$ bulk glass in a broad frequency range: 10 kHz-10 MHz.

2. Experimental

The samples investigated by electrical measurements were sawn from the ingots and polished with alumina powder and diamond paste. Evaporated aluminium films were used as electrodes and found to make ohmic contact with the samples. The size of a typical parallepiped sample was 7×6×2 mm^3. The a.c. conductivity measurements were carried out in, a impedance analyser Hewlett-Packard (frequency range: 100 Hz – 40 MHz) in dark, at room temperature. The frequency range of our measurements was 10 kHz-10 MHz.

3. Results and discussion

The frequency dependence of the a.c. conductivity in $As_2Te_{2.8}Si_{3.2}$ glass is shown in Fig. 1, as a double logarithmic plot.

The plot is nearly linear for low frequencies and changes towards a quadratic variation at higher frequencies. This is evidenced by the value of the slope s of the conductivity curve for various frequencies ranges. For very high frequencies a tendency toward saturation is observed.

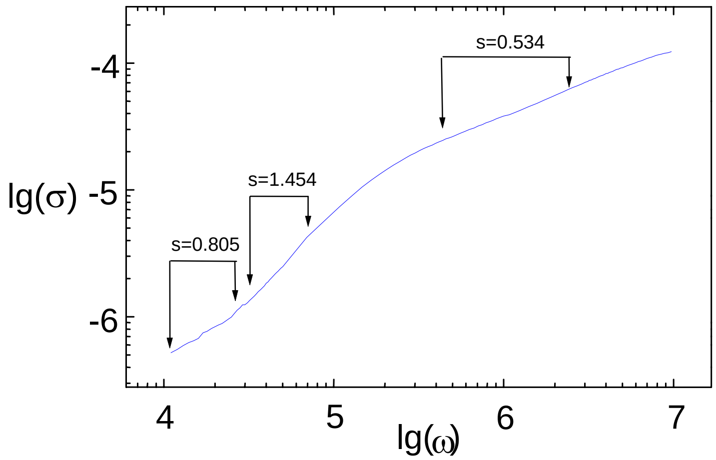

Fig. 1. The dependence of the conductivity of the bulk glass $As_2Te_{2.8}Si_{3.2}$ on the frequency of the applied electrical field.

An a.c. electrical conductivity having a frequency and chalcogenide dependence $\sim\omega^s$, where $s < 1$, has been reported for many amorphous semiconductors glasses.

The phenomena of increasing conductivity with increasing frequency may be interpreted by dispersions of Debye type, Maxwell-Wagner-type and by hopping conduction. As the Debye type dispersion is caused by the orientation of atomic dipoles, it is not probable for this type to occur largely in much semiconductors. The Maxwell-Wagner dispersion is caused by interfacial polarization set up from inhomogeneity of the material. The hopping conduction is a mechanism in which carriers transit from one localized state to another under the assistance of phonons. The Maxwell-Wagner dispersion and the hopping conduction are more favourable for the conduction mechanisms to take place in the disordered materials as is the case of our bulk glass $As_2Te_{2.8}Si_{3.2}$.

Davis and Mott [4] and Pollack[5] assumed that the measured conductivity for $As_2Te_4Si_2$, which has a band gap of ~1eV is due to conduction in localized states near the Fermi level.

Elliott [6] developed a theory of a.c. conduction in chalcogenide glasses. A model of two electrons hopping over a barrier is the appropiate one for a description of a.c. conductivity in the chalcogenide glasses. The Elliott's model predicts an a.c. conductivity whose frequency dependence is slightly sublinear.

The anomalous position of a-As_2Te_3 in having a very high a.c. conductivity is explained by the very small band-gap of this material as compared to other chalcogenide glasses. This is also the case of our glassy material based on $As_2Te_{2.8}$ alloyed with $Si_{3.2}$.

Later, Elliott [7] has shown that a mechanism of two electrons (bipolaron) hopping between oppositely charged defect states over a barrier, whose height is correlated with the intersite separation by the Coulomb interaction, satisfactorily account for salient features of a.c. conductivity in chalcogenide glasses and an atomic mechanism need not be invoked.

4. Conclusions

Strongly increasing conductivity with frequency is a good evidence, but not unambigous, for hopping conduction in ternary glass of composition $As_2Te_{2.8}Si_{3.2}$. An inhoumogenity mechanism would also lead to an increasing conductivity regardless of the conduction mechanism in the individual components.

Taking into account the results obtained in [3] on the possible inhomogeneities in the ternary sample studied, we suggest a mixed mechanism for a.c. conduction in the ternary glass based on tellurium.

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